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INDUSTRIAL DEVELOPMENT ORGANIZATION



Technical Guidelines for the
Development of Small Hydropower Plants
DESIGN

Part 9: Project Cost Estimates

SHP/TG 002-09:2019



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Further recommendations and suggestions for application for the update would be highly welcome.

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Foreword

The United Nations Industrial Development Organization (UNIDO) is a specialized agency under the United Nations system to promote globally inclusive and sustainable industrial development (ISID). The relevance of ISID as an integrated approach to all three pillars of sustainable development is recognized by the 2030 Agenda for Sustainable Development and the related Sustainable Development Goals (SDGs), which will frame United Nations and country efforts towards sustainable development in the next fifteen years. UNIDO's mandate for ISID covers the need to support the creation of sustainable energy systems as energy is essential to economic and social development and to improving quality of life. International concern and debate over energy have grown increasingly over the past two decades, with the issues of poverty alleviation, environmental risks and climate change now taking centre stage.

INSHP (International Network on Small Hydro Power) is an international coordinating and promoting organization for the global development of small hydropower (SHP), which is established on the basis of voluntary participation of regional, subregional and national focal points, relevant institutions, utilities and companies, and has social benefit as its major objective. INSHP aims at the promotion of global SHP development through triangle technical and economic cooperation among developing countries, developed countries and international organizations, in order to supply rural areas in developing countries with environmentally sound, affordable and adequate energy, which will lead to the increase of employment opportunities, improvement of ecological environments, poverty alleviation, improvement of local living and cultural standards and economic development.

UNIDO and INSHP have been cooperating on the World Small Hydropower Development Report since year 2010. From the reports, SHP demand and development worldwide were not matched. One of the development barriers in most countries is lack of technologies. UNIDO, in cooperation with INSHP, through global expert cooperation, and based on successful development experiences, decided to develop the SHP TGs to meet demand from Member States.

These TGs were drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of these TGs may be subject to patent rights. UNIDO and INSHP shall not be held responsible for identifying any such patent rights.

Introduction

Small Hydropower (SHP) is increasingly recognized as an important renewable energy solution to the challenge of electrifying remote rural areas. However, while most countries in Europe, North and South America, and China have high degrees of installed capacity, the potential of SHP in many developing countries remains untapped and is hindered by a number of factors including the lack of globally agreed good practices or standards for SHP development.

These Technical Guidelines for the Development of Small Hydropower Plants (TGs) will address the current limitations of the regulations applied to technical guidelines for SHP Plants by applying the expertise and best practices that exist across the globe. It is intended for countries to utilize these agreed upon Guidelines to support their current policy, technology and ecosystems. Countries that have limited institutional and technical capacities, will be able to enhance their knowledge base in developing SHP plants, thereby attracting more investment in SHP projects, encouraging favourable policies and subsequently assisting in economic development at a national level. These TGs will be valuable for all countries, but especially allow for the sharing of experience and best practices between countries that have limited technical know-how.

The TGs can be used as the principles and basis for the planning, design, construction and management of SHP plants up to 30MW.

- The Terms and Definitions in the TGs specify the professional technical terms and definitions commonly used for SHP Plants.
- The Design Guidelines provide guidelines for basic requirements, methodology and procedure in terms of site selection, hydrology, geology, project layout, configurations, energy calculations, hydraulics, electromechanical equipment selection, construction, project cost estimates, economic appraisal, financing, social and environmental assessments—with the ultimate goal of achieving the best design solutions.
- The Units Guidelines specify the technical requirements on SHP turbines, generators, hydro turbine governing systems, excitation systems, main valves as well as monitoring, control, protection and DC power supply systems.
- The Construction Guidelines can be used as the guiding technical documents for the construction of SHP projects.
- The Management Guidelines provide technical guidance for the management, operation and maintenance, technical renovation and project acceptance of SHP projects.

Technical Guidelines for the Development of Small Hydropower Plants

DESIGN

Part 9: Project Cost Estimates

1 Scope

This part of the Design Guidelines specifies how to formulate cost estimations for small hydropower (SHP) projects and details how to prepare cost estimation documents.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

SHP/TG 001, *Technical guidelines for the development of small hydropower plants —Terms and definitions.*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in SHP/TG 001 apply.

4 General provisions

4.1 Cost estimations of projects shall be formulated according to cost levels and policies applicable in the formulation year. In the case of major changes to the design plan and cost level in the commencement year of the project, the cost estimation shall be revised accordingly.

4.2 Investments related to social and environmental mitigation and protection shall be included in the total investment of the project after the estimation has been made, based on the relevant provisions of the social and environmental impact assessment.

4.3 Investments related to the transmission engineering from SHP to the substation of the power grid shall not be incorporated in the total investment of the project.

4.4 The project cost estimation at the feasibility study stage shall be prepared in accordance with the provisions of Chapters 5 to 8 of this document, and the investment estimation at the pre-feasibility study stage shall be prepared in accordance with the provisions of Chapter 9 of this document.

5 Project division

5.1 Overview

Cost estimations of a hydropower project can be divided into the construction part, and the social and environmental protection part. The construction part includes five subparts: construction of temporary works, construction of civil works, electromechanical equipment and installation, and hydro mechanical structure and installation and miscellaneous costs, as shown in Figure 1:

5.2 Composition of the construction part

5.2.1 Construction of temporary works

This refers to the temporary works built to assist the construction of the main works, which can be composed of the following components:

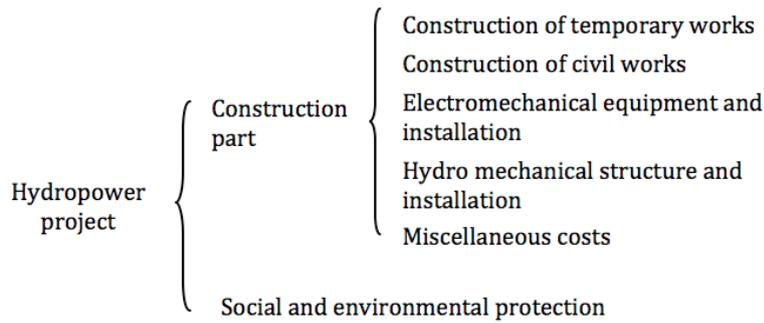


Figure 1 - Division of cost estimation of hydropower project

a) River diversion

This includes river diversion through an open channel, a diversion tunnel, glory hole, construction of the cofferdam (including river closure), hydro mechanical structure equipment, installation for construction diversion and temporary downstream water supply works, all taking place from the start of the impoundment and during the impoundment period.

b) Transportation during construction

This refers to the temporary transportation facilities constructed to serve the construction of the project within and outside the construction site, including special roads, bridges, construction adits, waterway works, reinforcement of bridges, culverts and roads, aerial cableways, ramp hoist ways, and the maintenance and management of permanent transportation works and temporary transportation facilities during the construction period of the power station.

c) Power for construction

This includes transmission lines that supply power from the existing power grid to the construction site, transmission lines of 10 kV and above on the construction site, and power supply facilities for outgoing lines of 10 kV and above. The power supply facilities include the construction of substations, substation equipment and their installation, as well as the supporting facilities.

d) Building of houses for construction and construction management

This refers to the construction of the houses and supporting facilities required for the construction personnel and construction management during project construction; it includes site levelling, construction of warehouses, auxiliary processing plant, non-residential and residential accommodation, project amenities (e.g. health, educational and recreational), as well as the maintenance and management of permanent and temporary buildings during the construction period of the power station. These are specified as follows:

- 1) Site levelling refers to earth-rock excavation and filling and masonry work carried out on the planned site for the purpose of building houses for construction and management, as well as for project amenities.
- 2) Construction of warehouses includes general warehouses and special warehouses. General warehouses are used for equipment, materials and tools, and special warehouses are used for oil depots and explosives depots.
- 3) Auxiliary processing plant includes wood processing plant, rebar processing plant, steel pipe processing plant, hydro mechanical structure processing plant, mechanical repair plant and precast concrete plant.
- 4) Non-residential and residential accommodation refers to the houses and supporting facilities built on the construction site for the personnel involved in construction management, supervision, and design and construction, to work and live in; all associated rental expenses incurred on the construction site during the construction period shall be included in this item.

e) Other construction temporary works

This refers to all temporary works other than those listed above, and mainly includes construction for water supply (large pump houses and mains pipes), air supply, aggregate production systems, concrete mixing and pouring systems, installation and removal of large heavy machinery, flood prevention, ice prevention, drainage systems and communication. Where such items involve high expenses or large quantities, they can be listed separately, depending on the needs of the project.

5.2.2 Construction civil works

Construction civil works refers to the main civil structures and other permanent structures, which may be composed of the following components, of which items a) to i) are the main construction works:

a) Water retaining (impoundment) /diverting structures

This includes all kinds of dams (weirs/barrages/storage dams) for retaining (impounding) and/or diverting water, and foundation treatment engineering.

The intake section of the dam for power generation, spillway section, seepage control of dam foundations and dam abutment, as well as the seepage control engineering of the reservoir bank, are all listed under this item. The non-overflow dam section, spillway section of the dam, intake section of the dam and foundation treatment engineering shall be listed respectively under concrete dam (sluice); the water-retaining dam section, dam body drainage structures, and foundation treatment engineering shall be listed respectively under earth (rockfill) dam. Excavation and slope stabilization within the excavation area of water retaining (impoundment) structures are included in this item.

b) Drainage and energy dissipation structures

This includes structures for flood discharge like spillways, flood discharge tunnels, sediment flushing (tunnel) and pressure relief holes (in tunnels), as well as the energy dissipation and anti-erosion structures along the side slopes of the intake and outlet, the slope and banks of the spillway and downstream of the drainage facilities behind the dam. Energy dissipation and anti-erosion structures can be divided into energy dissipation engineering (plunge pool and stilling basin), auxiliary energy dissipation engineering (baffle blocks, stilling tooth and auxiliary weir), apron extension, anti-scouring trench, pre-excavation and bank slope protection.

c) Water conductor system

This includes diversion open channels, water inlets (intakes - including gate chambers), diversion tunnels, surge chambers (shafts) or pressure forebays, penstocks, tail water surge chambers (shafts), tail water tunnels (channels), tail water outlets and other structures.

d) Power generation structures

This includes powerhouse foundations, powerhouse superstructures, grouting tunnels, drainage tunnels, ventilation tunnels (shafts) and other structures for the various power generation works on the surface and underground.

e) Power substation structures

This includes switchyards (surface or underground), bus ducts, ventilation tunnels, cable trench galleries (shafts), structures on outgoing line fields (or switchyard buildings) and other structures. If there is a converter station, it shall be placed parallel to the switchyard as a first-level project. The steel frame of the switchyard structures is included in this item.

f) Fish passage structure

This can be listed separately according to the layout of the main structures. The part combined with the barrage can also be a part of the barrage engineering.

g) Structures at the head of the irrigation channel

These can be listed separately according to the layout of the main structures. The part combined with the barrage can also be a part of the barrage engineering.

h) Treatment of slopes near the dam

This mainly includes the treatment of dam abutment slopes and landslides that will affect the safety of hydraulic structures, as well as the protection of the downstream bank slopes affected by the dissipation and scouring of discharged water and tailwater. The treatment of accumulation of large-scale landslide mass, steep slope failures and mudslides should be listed separately.

i) Transportation

This includes the transportation works for newly built permanent roads, bridges, tunnels and waterways to the dam, inside and outside the plant, as well as the reconstruction and reinforcement of existing roads and bridges.

j) Housing construction

This refers to the permanent building of houses serving for the management of on-site production and operation, including site levelling, ancillary workshops, warehouses, offices, on-duty apartments and ancillary facilities and outdoor works.

k) Other construction works

Other construction works include safety monitoring facilities, transmission lines, lighting lines, communication lines, and public facilities—like water supply, heat supply and drainage within the plant and dam area, labour safety and industrial health facilities, hydrological and sediment monitoring facilities, automatic water regime monitoring systems and others. These are specified as follows:

- 1) Safety monitoring facilities refers to all civil engineering carried out to complete the permanent safety monitoring system.

- 2) Transmission lines engineering refers to the overhead transmission lines, and cable trench engineering refers to the power cables starting from power plant to each production site. Power cables from power plant to each production site shall be included under electromechanical equipment and installation engineering.
- 3) Lighting line engineering refers to lighting lines and the facilities in the plant and dam area (including the lighting of outdoor substations), excluding the lighting facilities which have been listed respectively in the detailed structural components of hydraulic structures, such as barrage dams, spillways, and diversion and power generation systems.
- 4) Communication line engineering includes internal and external communication lines as well as special communication lines from the project to the hydrometric station and weather stations within the ambit of the power station (including the reservoir).
- 5) Labour safety and industrial health facilities refer to the permanent labour safety and industrial health facilities specially built to avoid hazards and harmful factors during the production and operation period; these mainly include safety signs, safety protection facilities, operating-environment safety-testing instruments, special control of noise and emergency facilities.

5.2.3 Electromechanical equipment and installation

This refers to all the electromechanical equipment and installation that constitutes the fixed assets of the power station; it may be composed of the following components:

a) Power generation equipment and installation

This includes turbine generator units and ancillary equipment, inlet valves, lifting equipment, auxiliary equipment for hydraulic machinery, electrical equipment, control and protection equipment, communication equipment and installation.

b) Switchyard equipment and installation

This includes main transformer, high voltage electrical equipment, primary cable and other equipment and installation.

c) Public utilities and installation

This includes communications equipment, ventilation and heating equipment, mechanical repairing equipment, computer monitoring systems, industrial television systems, management automation systems, the earthing and protection network for the whole plant, elevators, feeding equipment in the dam area, water supply, drainage and heating equipment in the plant and dam area, hydrology and sediment monitoring equipment, automatic water regime monitoring system equipment, video equipment for security monitoring, safety monitoring equipment, fire safety equipment, labour safety and industrial hygiene equipment, transportation equipment, and other equipment and installation.

5.2.4 Hydro mechanical structure and installation

This refers to the entirety of the hydro mechanical structure and installation that constitutes the fixed assets of the power station. The components of the hydro mechanical structure and their installation shall correspond to the components or subunits of the construction project, including gates, hoists and trash racks, the fabrication and installation of penstocks and other hydro mechanical structural items and installation, and any other associated equipment and installation.

5.2.5 Miscellaneous expenses

This includes construction management expenses, scientific research and experiment expenses, design expenses, engineering survey expenses, construction supervision expenses, economic and technological consultancy expenses, project insurance expenses and anti-terrorism measures expenses.

5.3 Division of the construction part

The division of the construction part of the project shall comply with the provisions of Appendix A.

6 Composition of expenses and unit costs

6.1 Overview

The composition of costs for the construction part is shown in Figure 2:

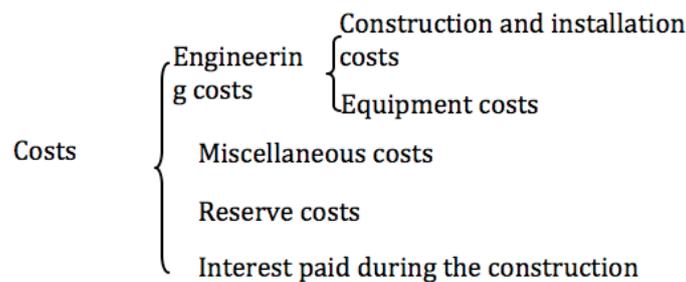


Figure 2 - Composition of cost estimates for construction

6.2 Construction and installation costs

6.2.1 Direct costs

These refer to the labour and capital which are directly consumed in the engineering project during the process of construction and installation. They may be composed of basic direct costs and other direct costs. The basic direct costs may include labour costs, material costs and construction machinery costs. Other direct costs may include additional costs for construction during winter and rainy seasons, additional costs for construction at night, additional costs for construction in special areas, amortization costs for small, temporary facilities, costs for safety and modern construction measures, as well as other costs.

a) Basic direct costs

1) Labour costs

This refers to various costs incurred by the production workers directly engaged in construction and installation. The production workers are generally composed of technical workers from the construction organization and labourers from elsewhere. Therefore, the unit cost of labour shall be calculated according to the respective proportions of workers from the construction organization and from the local workforce.

2) Material costs

Material cost price shall be formulated for key materials consumed in large quantities and/or which have a considerable influence on project investment. Examples are steel, timber, cement, asphalt, admixture, oil, fire work products, cables and bus bars. The cost price of materials = [material's original price + packing expenses + (transportation expenses × gross weight coefficient)] × (1 + procurement and storage cost rate) + transportation insurance premium - recycling value of packaging materials], where:

1) Original price refers to the market transaction price offered by the bulk material supply company or material trading centre in the nearby regions of the project, or the factory price offered by the manufacturer specified in the design.

2) Packaging costs shall be calculated according to the type, specification, packaging cost and normal amortization of packaging materials. Where the original price of materials does not cover packaging costs but the materials must be packed in the course of transportation and storage, the packaging costs shall be calculated separately. Transportation insurance premium refers to the insurance premium for materials in transportation, which is calculated according to the relevant regulations of the insurance company or a market survey.

3) Transportation expenses refers to all costs incurred from the designated delivery place to the warehouse or equivalent stockpile areas, including transportation, loading and unloading, and other incidental costs.

4) Gross weight of materials refers to the transport weight of materials including the weight of packages. The ratio of gross weight to net weight of materials is the gross weight coefficient. Material procurement and storage costs refer to all costs incurred during the process of material procurement, supply and storage.

5) Packaging recycling value refers to the recycling costs of packaging, such as cement bags, car stakes and cable trays.

6) The other cost price of materials can be determined by referring to the actual budgetary price of materials procured in similar hydropower projects in the same region.

3) Costs of construction machinery

This refers to the depreciation, maintenance, and power and fuel costs of the machinery used in construction and installation works. It may include basic depreciation expenses, equipment repair expenses, installation and disassembly expenses, on-board labour expenses and power and fuel expenses, among which:

1) Basic depreciation expenses refers to the depreciation amortization expenses for the recovery of the original value of construction machinery within the specified use period:

2) Equipment repair expenses refers to the costs of repairing and replacing: the equipment and miscellaneous equipment tools, lubricating materials required for daily maintenance, cleaning accessories and machinery storage costs incurred to maintain the normal functioning of construction machinery.

3) Installation and disassembly expenses refers to costs for installation and disassembly of construction machinery coming in and out of the site, test runs, the moving of machinery on the site and the amortized cost of auxiliary facilities.

4) On-board labour expenses refers to the expense of personnel working on machinery operation when construction machinery is being used.

5) Power and fuel expenses refers to the costs of air (compressed air), water, electricity, oil and coal required for normal operation.

b) Other direct expenses

This may include additional costs for construction during winter and rainy seasons, additional costs for construction at night, additional costs for construction in special areas, amortization costs for small temporary facilities, and costs for safety and modern construction measures, as well as other costs.

- 1) Additional costs for construction during winter and rainy seasons refers to the additional costs required to guarantee engineering quality and safety during the construction in winter and rainy seasons. This includes the costs for additional construction processes, additional construction of rainproof, heat preservation and drainage facilities, increased power and fuel consumption and the increased costs due to reduced labour and mechanical efficiency.
- 2) Additional costs for construction at night refers to the subsidy fees for night shifts incurred due to construction during the night, amortization of construction lighting equipment on the construction site and construction roads, as well as lighting electricity costs.
- 3) Additional costs for construction in special areas refers to the increased costs for construction in special areas, such as those involving high altitudes, natural forest, hot weather and sandstorms.
- 4) Amortization expenses of small temporary facilities refers to the amortization expenses of small temporary facilities used at work areas during the normal construction of the project, and includes erection and dismantling of scattered scaffolds, scattered site levelling, installation and removal of air, water and electricity distribution lines, construction drainage on site, maintenance of service roads, and erection and dismantling of temporary duty rooms.
- 5) Costs for safety and modern construction measures refers to the costs incurred by the construction enterprises when purchasing safety protective appliances, implementing safety measures, improving safety conditions and strengthening safety management during construction.
- 6) Other costs include expenses for construction tools and instruments, inspection and test expenses, engineering positioning and retest expenses (construction measurement and control network expenses), expenses for project delivery and acceptance, expenses for clearing the site upon completion and maintenance costs incurred before handover of the project.

Expenses for construction tools refers to the procurement, amortization and maintenance costs for manufacturing tools, and test and inspection instruments required for construction and production which are not included within fixed assets, as well as compensation charges for the use of workers' own tools, where:

- 1) Inspection and test expenses refers to the costs incurred by the construction enterprises in general identification and inspection of buildings, materials, components and building installations, in accordance with relevant standards, including the costs of materials used by external laboratories.
- 2) Other direct costs shall be calculated based on direct engineering costs, which shall be calculated at a rate of 5 per cent to 8 per cent; the rate shall be selected according to the complexity of the main engineering project and the temporary facilities.

6.2.2 Indirect expenses

Indirect expenses refers to the administrative expenses of construction enterprise management personnel carrying out office work, training, travel, labour protection, foreign affairs activities, performance guarantees and the handling of work permits for foreign personnel.

6.2.3 Profit

This refers to the profit, which shall be included in the construction and installation expense according to market trends affecting the hydropower construction project.

6.2.4 Taxes

This refers to business taxes, value added tax or other related costs, which shall be included in the construction and installation costs in accordance with the national tax laws and relevant provisions.

6.3 Equipment expenses

This includes the original price of equipment, domestic transportation and insurance costs of equipment in the manufacturing country, international transportation, as well as insurance premiums for equipment, tariffs and other costs, local transportation and insurance costs, and procurement and storage costs. If equipment is purchased directly from the domestic market, only local transportation and insurance costs, and procurement and storage costs, are calculated.

6.4 Formulation of unit cost of construction and installation engineering

The unit cost of construction and installation engineering may be calculated using the comprehensive unit price method. The contents of the unit cost of construction and installation engineering include direct costs, indirect costs, profit and tax. The direct costs, indirect costs, profit and tax shall be listed in the unit estimation table. Calculation procedures for the unit cost of construction and installation engineering are as follows:

a) Direct costs

Basic direct costs include labour costs, material costs and machinery costs.

Other direct costs = direct engineering costs × other direct cost rate.

b) Indirect costs = direct costs × indirect cost rate

c) Profit = (direct costs + indirect costs) × profit rate

d) Tax = (direct costs + indirect costs + profit) × tax rate

e) Unit price of construction project = direct costs + indirect costs + profit + tax

7 Formulation of cost estimation in construction

7.1 Construction temporary works

7.1.1 Diversion project

This is calculated according to the designed work quantities multiplied by the unit cost.

7.1.2 Construction transportation

This is calculated according to the designed work quantities multiplied by the unit cost , but it may also be formulated using an escalated unit-index, according to the cost index in the project area or related actual data.

7.1.3 Construction power supply

This is calculated according to the designed work quantities multiplied by the unit cost , but it may also be formulated using an escalated unit-index, by adopting the cost index in the project area or by analysing related actual data according to the designed voltage grade, line erection length and the requirements for transformer distribution facilities.

7.1.4 Building of houses for construction and construction management

The site leveling project costs shall be calculated according to the designed work quantities multiplied by the unit cost. Construction warehouse and auxiliary processing plant costs shall be calculated according to the designed work quantities multiplied by the unit cost index. The construction area of houses may be determined by construction planning. The unit cost index of building construction may employ the cost index of temporary houses in the region where the project is located, or is determined based on the analysis of actual data. Investment in non-residential and residential accommodation shall be determined by the designed work quantities multiplied by the unit cost index.

7.1.5 Other construction temporary works

This shall be calculated according to the percentage rate of the investment in construction and installation for the project (excluding other construction temporary works); a rate of 2 per cent to 3 per cent may be used. For projects with high costs and large engineering requirements, it may be listed separately, according to the actual requirements of the project, and the above-mentioned percentage rate can be decreased accordingly.

7.2 Construction project

7.2.1 Construction of main structure

The construction of the main structure shall be formulated according to the designed work quantities, multiplied by unit cost.

7.2.2 Transportation project

This may be calculated according to the designed work quantities multiplied by unit cost, or formulated with the escalated unit index according to cost index in the project area or related actual data.

7.2.3 Housing construction project

- a) The unit cost index for permanent housing construction shall be determined according to the local corresponding construction cost level.
- b) Outdoor housing construction works may generally be calculated as 15 to 20 per cent of the investment in the construction of houses.

7.2.4 Other project facilities

Safety monitoring facilities costs may be calculated according to the design information. If there is no design information, they may be calculated as a percentage of the investment in the construction of the main structure, based on a dam-type or other engineering-type project.

Dam built with local material	0.9% to 1.1%
Concrete dam	1.1% to 1.3%
Diversion structures (weirs/barrages)	1.1% to 1.3%

Investment in projects involving transmission lines, lighting lines and communication lines shall be formulated based on the designed work quantities multiplied by unit cost or the escalated unit index.

All other items are analysed and calculated according to their design requirements.

7.3 Electromechanical equipment and installation project

7.3.1 Equipment cost

Equipment cost is mainly composed of the following items:

- a) Original cost of equipment refers to the production cost or the retail cost after a product has been analysed and demonstrated by the designer, along with all applicable taxes, duties.
- b) Domestic transportation costs of equipment in its production country refers to all the transportation costs of equipment shipped from the manufacturer to a domestic port. It mainly includes transportation expenses, vehicle dispatching expenses, loading and unloading expenses, packing and binding expenses, nitrogen charging expenses for transformers and other incidental costs that may occur.
- c) Domestic transportation insurance premium refers to the insurance premium arising from the transportation process of the equipment. Transportation insurance premiums for equipment shall be calculated based on a percentage of the original cost of equipment, and the insurance rate shall be calculated according to the provisions of the relevant authorities.
- d) International transportation costs refers to all the transportation costs incurred by the equipment shipped from the supplier port to the relevant project port.
- e) International transportation insurance premium refers to the insurance expenses arising from the international transportation of the equipment.
- f) Tariff and other costs refers to the tariff, value-added tax, bank financing expenses, foreign trade expenses, import commodity inspection expenses and port charges imposed on the import of the equipment.
- g) Local transportation costs refers to all the transportation costs incurred by the equipment shipped from the domestic port (or the manufacturer) to the project site.

- h) Local transportation insurance premium refers to the insurance expenses of the equipment in the transportation process, which shall be calculated according to a market survey.
- i) Procurement and storage expense refers to all the costs arising from the procurement and storage of the equipment, which mainly includes procurement expenses, warehousing expenses, site storage expenses, depreciation costs of miscellaneous fixed assets, costs for technical safety measures, and the cost of equipment inspection and testing.
- j) Other considerations:
 - 1) Due to the weak economic bases of many countries where SHP projects are carried out, attention shall also be paid to whether the relevant port in the country has sufficient loading and unloading capacity, whether additional hoisting machinery is needed and whether the road infrastructure of the country meets the requirements for transporting large equipment.
 - 2) The field assembly and processing costs for the components of the main frame, after being transported to the site, are included in the original cost of equipment. If an assembly yard needs to be set up, its construction cost shall also be included in the original price of the equipment.
 - 3) If the equipment is purchased directly from domestic markets, only the local transportation and insurance premium, and procurement and storage expenses, need to be calculated.

7.3.2 Installation project expenses

Investments in installation projects shall be calculated based on the amount of equipment multiplied by the installation unit cost.

7.4 Hydro mechanical structure and installation

The formulation method is the same as that in Section 7.3.

7.5 Miscellaneous costs

Miscellaneous costs are mainly composed of the following items:

- a) Construction management expenses refers to the management expenses required for the entire process, from project preparation to completion acceptance, in order to conduct a normal construction project. They include the preliminary project inspection, form of construction organization, management equipment and equipment purchase, management staff wages and benefits, and other management costs. Consensus-building costs with stakeholders (including local people and communities) may be included within construction management expenses. They are included in the cost estimation on the basis of actual costs incurred, and may be calculated as 2 to 3 per cent of the investment covered by Sections 7.1 to 7.4 in cases where there is an absence of relevant information.
- b) Scientific research and experiment expenses refer to the costs required to carry out necessary scientific research and tests during the construction process to solve technical problems associated with the project. It is included in the cost estimation on the basis of actual costs incurred, and it may be calculated as 0.5 per cent of the investment in construction and installation covered by Sections 7.1 to 7.4, in cases where there is an absence of relevant information.

- c) Design expenses includes the costs for the provision of schemes, pre-feasibility study and cost estimation, feasibility study and cost estimation, detail design drawings and bills of quantities, technical presentation, handling of design problems during construction, preparation of as-built drawings and other services, as well as the costs for external design review and travel costs for design personnel. It shall be included in the cost estimation on the basis of actual costs or by reference to similar projects.
- d) Engineering investigation expenses refers to the costs for engineering geological exploration and surveying and mapping, which shall be included in the cost estimation on the basis of actual costs or with reference to similar projects.
- e) Supervision expenses includes the costs for the complete supervision and control service for construction quality, safety, progress and the cost of the parts of the project under direct supervision, as well as the costs of on-site construction supervision engineers, which are included in the cost estimation, on the basis of actual costs or with reference to similar projects.
- f) Economic and technical consultancy costs refers to the costs incurred by engaging qualified organizations or employing experts to consult, evaluate and estimate the technical, economic and legal issues associated with the project in terms of safety, reliability, advancement and economics of the project construction, according to the project-management objectives. It shall include special consultation on surveys and design outcomes, engineering safety and technical appraisal, special examination of construction and design changes, special assessment of quality problems during the construction and warranty period, labour safety and industrial health testing and evaluation, final accounts for completed project and post-evaluation reports on the project, and other consultation costs.
- g) Project insurance expenses refers to the insurance expenses of construction, equipment and installation works during the construction of the project in order to obtain economic compensation for the project if it suffers losses caused by fires, flood and other natural disasters, and accidental events. It shall be included in the cost estimation on the basis of actual costs incurred, and it can be calculated as 0.5 per cent of the investment covered by Sections 7.1 to 7.4 in the case of an absence of relevant information.
- h) Expenses for anti-terrorism measures refers to the expenses of security personnel and safety facilities designed to guarantee the personal safety, and safety of the property, of technical and management personnel, depending on safety requirements in the country.

7.6 Reserve fund and financing interest during construction period

7.6.1 Reserve fund

a) Basic reserve fund

The basic reserve fund is mainly designed to handle increased investments required by design changes and the adjustment of relevant technical standards during construction, any losses suffered by the project due to general natural disasters, as well as the costs of measures adopted for prevention of natural disasters. It can be calculated as 5 to 10 per cent of the total investment of the project from Sections 7.1 to 7.4.

b) Reserve fund for price differences

The reserve fund for price differences is mainly designed to handle increased investments during the construction process due to increases in wages, materials and equipment prices and the adjustment of expense standards. Depending on the construction period, the estimation base is the annual capital investment (including the basic reserve fund), and the reserve is calculated by the following formula.

- 1) When the annual cost indices are the same, the reserve fund for annual cost difference is calculated using the following formula:

$$E_i = F_i \left[(1 + p)^{i-1} - 1 \right] \dots\dots\dots (1)$$

- 2) When the annual cost indices are different, the reserve fund for annual cost difference is calculated using the following formula:

$$E_i = F_i \left[(1 + p_2)(1 + p_4) \dots (1 + p_i) - 1 \right] \dots\dots\dots (2)$$

- 3) The reserve fund for price differences is the sum of annual reserve fund for cost differences:

$$E = \sum_{i=1}^N E_i \dots\dots\dots (3)$$

where

- E is the reserve fund for cost differences;
- E_i is the reserve fund for cost difference in the i^{th} year;
- N is the construction period;
- i is the years of construction;
- F_i is the annual investment in the i^{th} year (including basic reserve fund);
- p is the average price index (applicable to the same annual price indices);
- p_i is the price index in the i^{th} year (applicable to different annual price indices);

The reserve fund for cost difference shall be calculated from the next year of the cost level year adopted to formulate budgets.

7.6.2 Financing interest during the construction period

Based on the reasonable construction period, taking the sum of annual investment, basic reserve fund and reserve fund for cost difference from section 5.1 to 5.4 of project budgetary estimation as the base number, the interest is calculated according to relevant fiscal and financial policies and the capital system used.

Estimation formula:

$$S = \sum_{n=1}^N \left[\left(\sum_{m=1}^n F_m b_m - \frac{1}{2} F_n b_n \right) + \sum_{m=0}^{n-1} S_m \right] i \dots\dots\dots (4)$$

where

- S is the financing interest during construction period;
- N is the reasonable construction period;
- n is the construction years;
- m is the interest repayment years;
- F_n, F_m is the investment of the n^{th} and m^{th} year in the capital flow table during construction period;

- b_n, b_m is the proportion of the financing amount for each construction year invested in the same year;
- i is the financing interest rate during construction period;
- S_m is the interest repayment amount in the m^{th} year.

Other financing costs such as commission fee, commitment fee, administrative fee, and credit insurance premium incurred through the financing of debt shall be analysed and calculated according to relevant provisions and shall be included in the interest of financing in the construction period.

8 Composition of cost estimation documents

8.1 Preparation instructions

8.1.1 Project profile

- a) The project profile briefly describes the river system where the project is located, construction site, accessibility, project scale, project benefit, project layout, work quantities of main structures, main material consumption, total construction period and schedule for power generation of the first (batch) unit.
- b) The project profile explains the sources of investment for project construction and the proportion of investment.
- c) The profile explains the total investment and static investment of the project, reserve fund for cost differences, financing interest during the construction period, investment per kW, investment per unit of electricity, and the total investment and static investment when the first (batch) unit starts power generation.

8.1.2 Preparation principles and basis

- a) The relevant national and regional laws and regulations adopted in the preparation of the cost estimation.
- b) The relevant regulations, norms and provisions used in the preparation of the cost estimation.
- c) The price-level year for the preparation of the cost estimation.
- d) Design documents and drawings.
- e) Other relevant provisions.

8.1.3 Basic price

- a) Estimated unit costs of labour, the estimated cost of the main materials, and the basic unit costs of electricity and water used for construction.
- b) Prices of major equipment.
- c) Expense calculation standards

8.1.4 Other considerations

Other issues to be addressed in the preparation of the cost estimation

8.1.5 Summary table of the main technical and economic indices

The main technical and economic indices of the project are listed in this table.

8.2 Project cost estimation table

The project cost estimation table may include the general cost estimation table, temporary construction project cost estimation table, cost estimation table for the construction project, cost estimation table for equipment and installation works, cost estimation table for miscellaneous expenses, annual investment summary table and the summary table of the main technical and economic indices. See Appendix B for the form of tables and requirements.

9 Preparation of investment estimation for the construction part

9.1 Preparation method and estimation standards

9.1.1 Basic unit cost

The preparation of the basic unit cost is the same as that used in budgetary estimation.

9.1.2 Unit cost of construction and installation projects

The preparation method for unit cost of construction and installation projects is the same as that used in budgetary estimation.

9.1.3 Preparation of subunit project estimations

Estimation of subunit projects can be divided into three parts, namely temporary construction projects, the construction project, and the electromechanical equipment and installation project:

- a) For temporary construction projects, the preparation method and estimation standards are essentially the same as those used in the cost estimation.
- b) For construction projects, the preparation of the investment estimation for the main construction works, transport engineering and building construction is basically the same as that in cost estimation. Other projects may be estimated as 2 to 4 per cent of the investment in the main construction works, depending on the particular nature and scale of the project.
- c) For electromechanical equipment and installation, the method for preparation of estimation of major electromechanical equipment and installation works is the same as that in the cost estimation. The equipment and installation costs of other electromechanical equipment can be calculated according to the percentage of the main electromechanical equipment cost or unit kilowatt index. Major electromechanical equipment includes turbines and ancillary equipment, generators and ancillary equipment, main valves, lifting equipment, generator circuit breakers, busbars, the main transformer and high voltage electrical equipment (which includes high voltage circuit breakers, high voltage combined electrical equipment, and high voltage power cables). Other electromechanical to electromechanical equipment other than the main electromechanical equipment, including hydraulic machinery ancillary equipment, electrical equipment, control and protection equipment, communications equipment, ventilation and heating

equipment, mechanical repair equipment, other substation equipment, elevators, feeder equipment in the dam area, water supply and drainage and heating supply equipment in the plant and dam areas, permanent hydrological telemetry equipment, permanent safety monitoring equipment, labour safety and industrial hygiene equipment, firefighting equipment, transportation equipment and plant earthing.

- d) For the hydro mechanical structure and installation works, the preparation method and estimation standards are essentially the same as those used in cost estimation.
- e) For miscellaneous expenses, the preparation method and estimation standards are essentially the same as those used in cost estimation.

9.2 Reserve fund and financing interest during the construction period

The requirements for the estimation of reserve fund and financing interest during the construction period are as follows:

- a) Basic reserve fund: A rate of 10 to 15 per cent may be used, with consideration of different design depths.
- b) Reserve fund for cost differences: Its estimation method is the same as that used for cost estimation.
- c) Financing interest during construction period: The estimation method here is the same as that used for cost estimation.

9.3 Composition of investment estimation documents

The investment estimation documents are composed of the preparation instructions and the investment estimation table. The table form and contents are essentially the same as those used in the cost estimation.

Note: The project investment estimation shall be prepared to make an informed decision for the development of the project in the early stages of the project. Investment estimation is essentially the same as preparing the cost estimation in terms of contents, project division and expenses composition. However, due to the different levels of detail in these two kinds of estimations, the preparation methods and estimation standards for each are different. Investment estimation shall therefore simplify, merge and adjust some of the content used for the preparation of the cost estimation.

Appendix A (Normative)

Project division in construction part

Table A.1 Item 1 - Temporary construction project

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
I	Diversion project			
1		Diversion open channel project		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/pack assembly
			Drilled grout hole	*/m
			Grouting	*/(t、 m、 m ²)
			Reinforced gabion	*/m ³
			Composite geomembrane	*/m ²
2		Diversion tunnel		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Plugging concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack assembly
			Drilled grout hole	*/m
			Grouting	*/(t、 m、 m ²)
			Waterstop	*/m
			Others	
3		Diversion shaft project		

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
4		Earth-rock cofferdam project		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Weir filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Seepage control	
			Removal of weir body	*/m ³
			Closure	
			Others	
5		Concrete cofferdam project		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Seepage control	
			Removal of weir body	*/m ³
			Others	
6		Downstream temporary water supply during the impoundment period		
7		Hydro mechanical structure and installation		
II	Construction transportation project			
1		Road		*/km
2		Railway		*/km
3		Bridge		*/m
4		Construction adit		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Concrete for plugging	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Anchor bolt (Assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/(t, m, m ²)

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
			Others	
5		Elevated ropeway		*/m
6		Ramp hoist way		*/m
7		Reinforcement of bridge and culvert and roads		*/km
8		Railway transfer station		*/Item
9		Waterway		*/Item
10		Maintenance and management of facilities		*/Item
III	Construction power supply project			
		High voltage power supply lines		*/km
		Substation		*/Piece
IV	Building of houses for construction and construction management			
		Site levelling		*/m ²
		General construction warehouses		*/m ²
		Explosive storage		*/Item
		Oil depot		*/Item
		Auxiliary processing plant		*/m ²
		Non-residential and residential accommodation		*/m ²
		project amenities		*/Item
		Maintenance and management of facilities		*/Item
V	Other temporary construction project			
NOTE ** indicates the currency unit				

Table A.2 Item 2 - Construction civil works

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
I	Water retaining (impoundment) structures			
1		Concrete dam (gate)		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (Assembly)	*/Piece
			Anchor cable	*/Pack
			Protective mesh	*/m ²
			Cutoff wall trenching	*/m ²
			Cutoff wall concrete	*/m ³
			Drilled grout hole	*/m
			Grouting	*/(t, m, m ²)
			Grouting orifice pipe	*/m
			Drainage hole	*/m
			Steel plate lining	*/kg
			Hoist room	*/m ²
			Temperature control measures	*/m ³ (concrete)
			Main structure	*/m ³
2		Earth (rock) dam		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth filling	*/m ³
			Sand-gravel filling	*/m ³
			Sloping (core) wall earth filling	*/m ³
			Filter material and graded material filling	*/m ³
			Dam rock filling	*/m ³
			Blanket filling	*/m ³
			Geomembrane	*/m ²
			Stone masonry	*/m ³
			Asphalt concrete	*/m ³

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Waterstop	*/m
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack assembly
			Protective mesh	*/m ²
			Cutoff wall trenching	*/m ²
			Cutoff wall concrete	*/m ³
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m
			Main structure	*/m ³
3		Reservoir bank seepage control project		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/pack assembly
			Protective mesh	*/m ²
			Cutoff wall trenching	*/m ²
			Cutoff wall concrete	*/m ³
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Grouting orifice pipe	*/m
			Drainage hole	*/m
II	Drainage and energy dissipation structures			
1		Spillway		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/pack
			Protective mesh	*/m ²
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m
			Steel plate lining	*/kg
			Temperature control measures	*/m ³ (Concrete)
			Main structure	*/m ³
2		Flood discharging tunnel		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack assembly
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m
			Steel plate lining	*/kg
			Main structure	*/m ³
3		De-silting chamber (tunnel)		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack assembly
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
			Main structure	*/m ³
4		Earth-rock cofferdam project		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack assembly
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m
			Main structure	*/m ³
5		Plungepool, auxiliary weir and stilling basin		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack assembly
			Protective mesh	*/m ²
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m
			Steel plate lining	*/kg
			Main structure	*/m ³
III	Water conductor system			
1		Diversion open channel		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack assembly
			Drainage hole	*/m
			Main structure	*/m ³
2		Inlet (intake) project		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Protective mesh	*/m ²
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m
			Main structure	*/m ³
3		Diversion tunnel	Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m
			Main structure	*/m ³
4		Surge shaft (chamber)	Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
			Shotcrete	*/m ³
			Grouting	*/m ²
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m
			Main structure	*/m ³
5		Pressure forebay		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (Assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m
			Main structure	*/m ³
6		Penstock		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and Placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Main structure	*/m ³
7		Tail water tunnel		Refer to diversion tunnel engineering series
8		Tail water surge chamber (shaft)		Refer to pressure regulation well (room) engineering series

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
9		Tail water channel		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Main structure	*/m ³
10		Tail water outlet		Refer to the listed items of inlet (intake) mouth engineering
IV	Power generation structures			
1		Ground plant engineering		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/ (t、 m、 m ²)
			Drainage hole	*/m
			Temperature control measures	*/m ³ (concrete)
			Structure decoration	*/m ²
			Main structure	*/m ³
3		Grouting tunnel		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/ (t, m, m ²)
			Drainage hole	*/m
			Main structure	*/m ³
4		Drainage tunnel		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/ (t, m, m ²)
			Drain hole	*/m
			Main structure	*/m ³
(II)	Underground power generation structures			
1		Power generation foundation project		
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Grouting	*/m ²
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/ (t, m, m ²)
			Drainage hole	*/m
			Temperature control measures	*/m ³ (Concrete)
			Structure decoration	*/m ²

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
			Main structure	*/m ³
V	Switchyard structures			
1		Surface substation		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Brick masonry	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Structure decoration	*/m ²
			Main structure	*/m ³
VI	Irrigation head works			
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Drainage hole	*/m
			Main structure	*/m ³
VII	Slope protection (near the dam)			
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Fabrication and placement of reinforcement	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Protective mesh	*/m ²
			Drilled grout hole	*/m
			Grouting	*/ (t, m, m ²)
			Drainage hole	*/m
			Others	
VIII	Transport engineering			
1		Road		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Earth-rock filling	*/m ³
			Stone masonry	*/m ³
			Concrete	*/m ³
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Protective mesh	*/m ²
			Others	
2		Railway		*/km
3		Bridge		*/m
4		Access tunnel (including access tunnel to the plant)		
			Earth excavation	*/m ³
			Rock excavation	*/m ³
			Concrete	*/m ³
			Fabrication and placement of rebar	*/kg
			Shotcrete	*/m ³
			Wiremesh rebar	*/kg
			Anchor bolt (assembly)	*/Piece
			Anchor cable	*/Pack
			Drilled grout hole	*/m
			Grouting	*/ (t, m, m ²)
			Main structure	*/m ³
5		Waterway		*/Item
IX	Building construction project			
		Site levelling		*/Item

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
		Auxiliary manufacturing plant		*/m ²
		Warehouse		*/m ²
		Office		*/m ²
		On-duty apartment and ancillary facilities		*/m ²
		Project amenities		%
		Manufacturing and operation management facilities		*/Item
		Cascade reservoirs control centre		*/Item
X	Other construction project			
		Safety monitoring facilities		
		Transmission line		*/km
		Lighting line		*/km
		Communications line		*/km
		Labour safety and industrial health facilities		
		Water level and sediment monitoring facilities		
		Automatic water regime monitoring system		
		Others		
NOTE **indicates the currency unit				

Table A3 Item 3 - Electromechanical equipment and installation project

Level-1 item	Level-2 item	Level-3 item	Technical and economic index
Generating equipment and installation project	Turbine equipment and installation	Turbine	*/Unit
		Speed regulator	*/Unit
		Oil pressure device	*/Set
		Automation element	*/Set
		Turbine oil	*/kg
		Generator equipment and installation	Generator
		Excitation system	*/Set
		Automation element	*/Set
	Main valve equipment and installation	Butterfly valve	*/Unit
		Spherical valve	*/Unit
		Oil pressure device	*/Set
		Lifting equipment and installation	Bridge crane/Gantry crane
		Balance beam	*/kg (Pair)
		Track	*/Pair 10m
		Track blocker	*/kg
		Flexible cable	*/Three phase 10m
	Hydraulic machinery auxiliary equipment and installation	Oil system	
		Compressed air system	
		Water system	
		Hydraulic measuring system	
		Pipeline (pipe, fittings and valve)	*/kg
		Electrical equipment and installation	Power generation voltage device
		Busbar	*/Single phase 100m
		Plant power system	

Level-1 item	Level-2 item	Level-3 item	Technical and economic index
		testing equipment	
		Power transmission cable	*/km
		Cable tray (cable and busbar)	*/kg
		Others	
	Control protection equipment and installation		
		Computer monitoring system	
		Protection system	
		Video monitoring system	
		Direct current system	
		Control and protection cable	*/km
		Others	
	Communication equipment and installation		
		Satellite communication	
		Optical fibre communication	
		Microwave communication	
		Carrier wave communication	
		Mobile communication	
		Manufacturing dispatching communication	
		Manufacturing management communication	
Switchyard equipment and installation project			
	Main transformer equipment and installation		
		Transformer	*/Unit
		Track	*/Pair 10m
		Track blocker	*/kg
	High voltage electrical equipment and installation		
		High voltage circuit breaker	*/Unit
		Current transformer	*/Unit
		Voltage transformer	*/Unit
		Isolation switch	*/Unit
		Lightning arrester	*/Unit

Level-1 item	Level-2 item	Level-3 item	Technical and economic index
		High voltage combined electrical equipment	*/Interval
		High voltage power cable	*/Three phase 100m
		Fabrication and installation of high voltage power cable head	*/Three phase set
	Wiring and other installation works		
Safety monitoring equipment and installation project			
Hydrological telemetry equipment and installation project			
Firefighting equipment and installation project			
Labour safety and industrial hygiene equipment and installation project			
Other equipment and installation project			
	Elevator equipment and installation		
	Feeder equipment in dam area and installation		
		Transformer	*/Unit
		Power distribution device	
	Water supply and drainage equipment in plant and dam area and installation		
	Heating equipment in plant and dam area and installation		
	Ventilation and heating equipment and installation		
	Machinery repair equipment and installation		
	Traffic equipment		*/Vehicle (Unit)
	Plant earthing		*/kg
	Others		*/Item
NOTE “*” indicates the currency unit			

Table A.4 Item 4 - Hydro mechanical equipment and installation project

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
I	Water retaining (impoundment) structures			
1		Gates and installation		
			Plain batten gate	*/kg
			Arch gate	*/kg
			Embedded parts	*/kg
			Gate weights	*/kg
2		Hoist equipment and installation		
			Winch hoist	*/Unit
			Gantry crane	*/Unit
			Oil pressure hoist	*/Unit
			Track	*/Pair 10m
			Track blocker	*/kg
3		Trash holding equipment and installation		
			Trash rack	*/kg
			Trash remover (cleaner)	*/kg (Set)
II	Drainage and energy dissipation structures			
1		Gates and installation		
2		Hoist equipment and installation		
3		Trash holding equipment and installation		
III	Water conductor system			
1		Gates and installation		
2		Hoist equipment and installation		
3		Trash holding equipment and installation		
4		Steel pipe (penstock) fabrication and installation		
IV	Switchyard structures			
		Steel framework		*/kg
V	Structures at head of irrigation channel			
1		Gates and installation		
2		Hoist equipment and installation		
NOTE "*" indicates the currency unit				

Table A.5 Item 5 - Miscellaneous costs

S/N	Level-1 item	Level-2 item	Level-3 item	Technical and economic index
1	Construction management expense			
2	Scientific research testing expense			
3	Design expense			
4	Engineering survey expenses			
5	Construction supervision expenses			
6	Economic and technical consultation expenses			
7	Insurance expenses of project			
8	Anti-terrorism measures expenses			

NOTE 1 In the project division, three levels—Level-1, Level-2 and Level-3—are completed for each item; these can be tailored to the project requirements, but Level-1 and Level-2 items shall not be merged. Items not specified in the table can be listed depending on actual project requirements.

NOTE 2 Only representative sub-items are listed under Level-3 items. When the design budgetary estimation is prepared, the following items shall be subdivided as necessary:

- ① Open excavation and underground excavation, earth excavation, and sand and gravel excavation shall be listed separately under earth excavation.
- ② Open excavation and underground excavation, as well as the excavation of adits, inclined shafts and vertical shafts shall be listed separately under rock excavation.
- ③ Earth filling and rock filling shall be listed, respectively, under earth-rock filling.
- ④ Different construction positions, different strength levels and different grades of the concrete works shall be listed, respectively.
- ⑤ Dry stone masonry, cement-laid stone masonry, riprap and wire (reinforcement) cage block stone shall be listed, respectively, under stone masonry.
- ⑥ Borehole grouting shall be listed separately according to the purposes and the different drilling machines employed.
- ⑦ Grouting projects shall be listed according to different grouting types, such as contact grouting, consolidation grouting, curtain grouting and backfill grouting.
- ⑧ Shotcrete-bolt support work, steel fibre shotcrete and plain shotcrete, anchor bolt and anchor cable, as well as any different specifications among them, shall be listed separately.
- ⑨ Electromechanical equipment and installation, as well as hydro mechanical structures and installation, shall be listed one by one, according to the equipment list required by the design and the item division requirements.
- ⑩ General steel pipe, branch pipe, and different pipe diameters and thicknesses shall be listed separately for steel pipe fabrication and installation.

NOTE 3 The composition of each part of the ecological substation shall be included within the corresponding items of the main project, according to their attributes.

NOTE 4 “*” indicates the currency unit

Appendix B (Normative) Project cost estimation table

B.1 Total cost estimation table

Unit: *

S/N	Description of project or expense	Construction and installation expense	Equipment procurement expense	Miscellaneous expense	Total
I	Investment in the construction part				
1	Temporary construction works				
2	Construction				
3	Electromechanical equipment and installation				
4	Hydro mechanical equipment and installation				
5	Miscellaneous expenses				
	Total investment:Item 1 to Item 5				
	Basic reserve fund				
	Total capital investment				
II	Social and environmental protection part				
	Investment in social and environmental protection				
	Basic reserve fund				
	Total capital investment				
III	Total investment in engineering (Total of I and II)				
	Total capital investment				
	Reserve fund for price differences				
	Financing interest during construction period				
	Total investment				
NOTE ** indicates the currency unit					

B.2 Cost estimation table of temporary construction project (or construction civil works)

Unit: *

S/N	Description of project or expense	Unit	Quantity	Unit price	Total

NOTE 1 Level III items are listed in this table according to the project division, and this table is applicable to temporary construction projects and construction civil works.
NOTE 2 "*" indicates the currency unit

B.3 Cost estimation table for equipment and installation projects

Unit: *

S/N	Description and specification	Unit	Quantity	Unit price		Total	
				Equipment	Installation	Equipment	Installation

NOTE 1 Level III items are listed in this table according to the project division and this table is applicable to electromechanical equipment and installation as well as hydro mechanical equipment and installation projects.
NOTE 2 "*" indicates the currency unit

B.4 Cost estimation table for miscellaneous expense

Unit:*

S/N	Description of project or expense	Estimation formula	Amount

NOTE "*" indicates the currency unit

B.5 Unit cost estimation table

Unit price S/N				
Project name				
Construction method				
Items	Unit	Unit price (*)	Quantity	Total price (*)
labour				
....				
Material				
....				
Construction machinery				
....				
Subtotal of basic direct expenses	*			
Other direct expenses	*	%		
Indirect expenses	*	%		
Profit	*	%		
Tax	*	%		
Total	*			
Unit price	*			
NOTE “*” indicates the currency unit				

B.6 Annual investment summary table

Unit: *

S/N	Description of project or expense	Total	Construction period (year)			
			1	2	3
I	Investment in construction part					
1	Construction temporary works					
2	Construction civil project					
3	Electromechanical equipment and installation					
4	Hydro mechanical structure and installation					
5	Miscellaneous expenses					
	Total investment: total of Items 1 to 5					
	Basic reserve fund					
	Total capital investment					
II	Social and environmental protection part					
	Investment in environmental protection					
	Basic reserve fund					
	Total capital investment					
III	Total investment of project(total of I and II)					
	Total capital investment					
NOTE "*" indicates the currency unit						

B.7 Main economic and technical index table

River system			Power Plant	Type		
Construction location				Size of powerhouse (length× width× height)	m×m×m	
Designer				Turbine model		
Project owner				Installed capacity (unit capacity × set)	kW	
Reservoir	Normal pool level	m		Guaranteed output	kW	
	Total pool capacity	m ³		Annual output	kW.h	
	Live capacity	m ³		Annual utilization of hours	h	
	Submerged cultivated land	Hectare		Construction engineering investment	*	
	Resettlement of residents	Person		Construction engineering per unit kW index	*/kW	
	Resettlement cost	*		Investment in power generation equipment	*	
	Unit index	*/Person	Power generation equipment per unit kW index	*/kW		
River weir (Gate)	Type		Excavation	Open earth-rock excavation	m ³	
	The maximum of dam height/ length of dam crest	m		Rock excavation in tunnel	m ³	
	Dam volume	m ³	Filling	Earth and rock	m ³	
	Investment	*		Concrete	m ³	
	Unit index	*/m ³	Cement		t	
Diversion tunnel	Type		Rebar and steel		t	
	Diameter	m	Timber		m ³	
	Length/Number		Fly ash		t	
	Investment	*	Explosives		t	
	Unit index	*/m	Fuel material		t	
Static total investment in the engineering		*	Total number of personnel	Personnel in peak period		Person
Total investment of project		*		Average		Person
Capital investment in unit kW		*		Total labour hours		Labour hours

Investment of unit annual output	*	Total construction progress	Project preparation period	Month
Capital investment in the first turbine generator unit for power generation	*		Construction preparation period	Month
Total investment in the first turbine generator unit for power generation	*		Main construction period	Month
Interest during construction	*		Project completion period	Month
Investment in transmission engineering	*		Construction period for power generation of the first turbine generator unit	Month
Production Department Personnel	Persons		Total construction period	Month
NOTE “*”indicates the currency unit				



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